

## CLAIMS

What is claimed is:

1. A low cost adaptive multi-beam and multi-diversity antenna array comprising:  
a plurality of antenna elements, said elements providing a plurality of beams, each of said beams selectively having diverse characteristics; and  
an integrated feed network feeding said elements from an input and providing adaptive beam forming for said plurality of beams, said feed network comprising switched phase shifters.
2. The array of claim 1 wherein said beams are selectively defined in different directions.
3. The array of claim 1 wherein said characteristics include beam polarization.
4. The array of claim 1 wherein said characteristics include beam width.
5. The array of claim 1 wherein said array is defined within a panel.
6. The array of claim 1 wherein said feed network is defined on a printed circuit board.
7. The array of claim 6 wherein at least a portion of each of said antenna elements are defined on said printed circuit board.
8. The array of claim 1 wherein said array is a wireless local area network antenna array.
9. The array of claim 1 wherein said feed network employs diodes as switches.
10. The array of claim 9 wherein said diodes are disposed in said phase shifters in a back-to-back configuration.
11. The array of claim 10 wherein said diodes are PIN diodes.
12. The array of claim 1 wherein said array is multi-band.
13. The array of claim 12 wherein the bands share an aperture.

14. The array of claim 12 wherein elements for different bands are interleaved.
15. The array of claim 1 wherein said array is broadband.
16. The array of claim 15 wherein said array has high manufacturing tolerances due to said array being broadband.
17. The array of claim 1 wherein said elements are arranged to provide reduced coupling.
18. The array of claim 1 wherein said elements comprise patch antenna elements.
19. The array of claim 18 wherein said patch elements comprise stacked patch antenna elements.
20. The array of claim 19 wherein said stacked patch antenna elements comprise a parasitic element larger than a feed element.
21. The array of claim 20 wherein said stacked patch element comprises a cross-shaped feed element.
22. The array of claim 21 wherein said cross-shaped feed elements provide reduced mutual coupling between elements.
23. The array of claim 20 wherein said stacked patch element comprises a cross shaped parasitic element.
24. The array of claim 20 wherein said stacked patch element comprises a generally square parasitic element.
25. The array of claim 19 wherein said parasitic element is spaced in a range of 0.3 to 0.8 wavelengths from said feed element.
26. The array of claim 18 wherein said antenna elements comprise diversity monopole elements.
27. The array of claim 26 wherein said diversity monopole elements comprise a monopole feed element and a ground providing a differential path.

28. The array of claim 27 wherein said ground is a ground plane supporting said feed network.
29. The array of claim 27 wherein said monopole feed element define a planer disc and are ultra wideband.
30. The array of claim 27 wherein said monopole feed elements define a plurality of rings and are multi-band.
31. The array of claim 27 wherein said monopole feed elements define a square and are broadband.
32. The array of claim 1 further comprising a reflector positioned behind said elements.
33. The array of claim 22 wherein said reflector is a ground plane.
34. The array of claim 1 wherein said antenna elements comprise slot integrated patch antenna elements.
35. The array of claim 34 wherein said slot integrated patch antenna elements are feed to provide branch diversity.
36. The array of claim 34 wherein said slot integrated patch antenna elements are feed to provide polarization diversity.
37. The array of claim 34 wherein said slot integrated patch antenna elements are feed to provide branch diversity and polarization diversity.
38. The array of claim 1 wherein each of said antenna elements comprise an integrated magnetic dipole and electric dipole.
39. The array of claim 38 wherein said magnetic dipole is provided by slots defined in grounded material.
40. The array of claim 39 wherein said electric dipole is disposed in said slots.

41. The array of claim 40 wherein said slots are spaced apart and said electric dipole comprises two electric monopoles disposed in said slots.
42. The array of claim 1 wherein spacing of said elements is optimized for scanning angle and gain.
43. The array of claim 42 wherein optimal element spacing is 0.64 wavelengths.
44. The array of claim 1 wherein said array is disposed on a flat surface.
45. The array of claim 1 wherein said array is disposed on a curved surface.
46. The array of claim 1 wherein panels making up said array are disposed at angles relative to one another to define a curved array.
47. The array of claim 1 further comprising directors extending a scanning angle of said array.
48. The array of claim 47 wherein a printed circuit board defining said feed network and supporting said elements support said directors.
49. The array of claim 47 wherein a ground plan reflector disposed behind said elements does not extend behind said directors, thereby aiding steering of beams along a plane of said array.
50. The array of claim 49 further comprising at least one angular reflector disposed at a termination of said ground plane reflector to provide higher gain and optimize tuned beam widths.
51. The array of claim 1 wherein said phase shifters define a plurality of line lengths to provide phase shifts by switching between said lines.
52. The array of claim 51 wherein said line lengths are provided by reduced size phase shift lines.
53. The array of claim 52 wherein ones of said reduced size phase shift lines are combined in paths through a phase shifter to provide desired phase shift paths.

54. The array of claim 51 wherein said phase shifts are discrete.
55. The array of claim 51 further comprising diodes disposed in line lengths to provide isolation of between said lines.
56. The array of claim 55 further comprising diodes disposed in line lengths, spaced apart from junctions of said line lengths to provide isolation between said lines.
57. The array of claim 55 further comprising diodes disposed in line lengths, spaced apart from junctions of said line lengths to prevent opposite phased power leakage cancellation between different ones of said lines.
58. The array of claim 55 further comprising diodes disposed in line lengths, spaced apart from junctions of said line lengths to cancel resonance effects in said lines.
59. The array of claim 1 wherein said feed network feeds said elements in two orthogonal branches.
60. The array of claim 59 wherein said feed network comprises a phase shifter to provide two orthogonal phases and a switch to selectively feed one of said orthogonal branches.
61. The array of claim 1 wherein said feed network comprises differential feeds for said elements.
62. The array of claim 61 wherein said differential feeds for said elements provide signals to said element 180 degrees out of phase.
63. The array of claim 1 further comprising controls having fault detection provided by current sensing to assess the current drawn by said phases shifters of said feed network to determine proper operation of said feed network phase shifters.

64. A low cost adaptive multi-beam and multi-diversity antenna array panel comprising:

a plurality of antenna elements defined at least in part on a printed circuit board, said elements providing a plurality of beams, each of said beams selectively having diverse characteristics; and

a feed network defined on said printed circuit board, said feed network feeding said elements from an input and providing adaptive beam forming for said plurality of beams, said feed network comprising switched phase shifters.

65. The panel of claim 64 wherein said panel provides a wireless local area network antenna array.

66. The panel of claim 64 wherein said phase shifters employs PIN diodes as switches.

67. The panel of claim 64 wherein said array is multi-band with the bands sharing a common aperture.

68. The panel of claim 67 wherein elements for different bands are interleaved on said printed circuit board.

69. The panel of claim 64 wherein said elements are adapted to fit on said panel.

70. The panel of claim 64 wherein said elements are arranged to provide reduced coupling.

71. A low cost adaptive multi-band, multi-beam and multi-diversity antenna array comprising:

a plurality of lower frequency antenna elements, said lower frequency elements providing a plurality of lower frequency beams, each of said lower frequency beams selectively having diverse characteristics;

a plurality of higher frequency antenna elements interleaved with said lower frequency elements, said higher frequency elements providing a plurality of higher frequency beams, each of said higher frequency beams selectively having diverse characteristics; and

an integrated feed network feeding each of said plurality of elements from a separate input and providing adaptive beam forming for said plurality of beams, said feed network comprising switched phase shifters.

72. The array of claim 71 wherein said lower frequency beams and said higher frequency beams share an aperture of said array.

73. The array of claim 71 wherein said array is a wireless local area network antenna array.

74. A low cost adaptive multi-beam and multi-diversity wireless local area network antenna array panel comprising:

a plurality of antenna elements defined at least in part on a printed circuit board, said elements providing a plurality of beams, each of said beams selectively having diverse characteristics; and

a feed network defined on said printed circuit board, said feed network feeding said elements from an input and providing adaptive beam forming for said plurality of beams, said feed network comprising switched phase shifters.

75. The panel of claim 74 wherein said array is multi-band with the bands sharing a common aperture.

76. The panel of claim 75 wherein elements for different bands are interleaved on said printed circuit board.

77. The panel of claim 74 wherein said elements are adapted to fit on said panel.

78. The panel of claim 74 wherein said elements are arranged to provide reduced coupling.

79. A method for adaptively providing multiple antenna beams having multi-diversity at low cost, said method comprising:

feeding a plurality of antenna elements with a switched phase shifter feed network;  
providing, by said elements, a plurality of antenna beams, each of said beams selectively having diverse characteristics;

providing by said feed network adaptive beam forming for said plurality of beams;

80. The method of claim 79 further comprising selectively defining said beams in different directions.

81. The method of claim 79 wherein said characteristics include beam polarization.

82. The method of claim 79 wherein said characteristics include beam width.

83. The method of claim 79 wherein said feeding further comprises employing diodes as switches.

84. The method of claim 83 wherein said employing further comprises disposing said diodes in said phases shifters back-to-back.

85. The method of claim 79 wherein said providing further comprises providing, by said elements, antenna beams of a plurality of bands.

86. The method of claim 85 wherein said bands share an antenna aperture.

87. The method of claim 85 further comprising interleaving elements for different bands.

88. The method of claim 79 further comprising arranging said elements to reduced mutual coupling between elements.

89. The method of claim 79 further comprising defining said plurality of antenna elements and said feed network, at least in part, on a same printed circuit board.



90. The method of claim 79 wherein said providing further comprises providing a plurality of lower frequency beams, employing a plurality of lower frequency ones of said antenna elements, ones of said lower frequency beams selectively having diverse characteristics, and providing a plurality of higher frequency beams, employing a plurality of higher frequency ones of said antenna elements, ones of said higher frequency beams selectively having diverse characteristics.

91. The method of claim 90 wherein said feeding further comprises feeding said plurality of lower frequency elements and said plurality of higher frequency elements from a separate input.

92. The method of claim 79 wherein said elements comprise patch antenna elements.

93. The method of claim 92 wherein said patch elements comprise stacked patch antenna elements.

94. The method of claim 93 wherein said stacked patch antenna elements comprise a parasitic element larger than a feed element.

95. The method of claim 94 wherein said stacked patch element comprises a cross-shaped feed element.

96. The method of claim 95 wherein said cross-shaped feed elements provide reduced mutual coupling between elements.

97. The method of claim 93 wherein said stacked patch element comprises a cross shaped parasitic element.

98. The method of claim 93 wherein said stacked patch element comprises a generally square parasitic element.

99. The method of claim 92 wherein said antenna elements comprise diversity monopole elements.

100. The method of claim 99 wherein said diversity monopole elements comprise a monopole feed element and a ground providing a differential path.

101. The method of claim 100 further comprising providing a wherein said ground is a ground plane supporting said feed network.

102. The method of claim 79 further comprising a reflector positioned behind said elements.

103. The method of claim 102 wherein said reflector is a ground plane.

104. The method of claim 79 wherein said antenna elements comprise slot integrated patch antenna elements.

105. The method of claim 104 further comprising:  
feeding said slot integrated patch antenna elements to provide at least one of branch diversity and polarization diversity.

106. The method of claim 79 wherein each of said antenna elements comprise an integrated magnetic dipole and electric dipole.

107. The method of claim 106 further comprising:  
defining slots in grounded material to provide said magnetic dipole.

108. The method of claim 107 further comprising:  
disposing said electric dipole in said slots.

109. The method of claim 108 further comprising:  
spacing said slots apart; and  
disposing electric monopoles in said slots to provide said electric dipole.

110. The method of claim 79 further comprising:  
optimizing said spacing of said elements for scanning angle and gain.

111. The method of claim 110 wherein optimal element spacing is 0.64 wavelengths.

112. The method of claim 79 further comprising:  
providing directors extending a scanning angle of an array comprised of said elements.

113. The method of claim 112 further comprising:  
supporting said directors with a printed circuit board defining said feed network and  
supporting said elements.

114. The method of claim 112 further comprising:  
aiding steering of beams along a plane of said array by disposing a ground plane reflector  
behind said elements to not extend behind said directors.

115. The method of claim 114 further comprising:  
providing higher gain and optimizing tuned beam widths using at least one reflector  
disposed at a termination of said ground plane reflector.

116. The method of claim 79 further comprising:  
defining a plurality of line lengths in said phase shifters to provide phase shifts by  
switching between said lines.

117. The method of claim 116 wherein said line lengths are reduced size phase shift  
lines.

118. The method of claim 117 further comprising:  
combining ones of said reduced size phase shift lines in paths through a phase shifter to  
provide desired phase shift paths.

119. The method of claim 116 wherein said phase shifts are discrete.

120. The method of claim 116 further comprising:  
disposing diodes in said line lengths to provide isolation of between said lines.

121. The method of claim 120 further comprising:  
disposing said diodes in said line lengths, spaced apart from junctions of said line lengths  
to provide said isolation between said lines.

122. The method of claim 120 further comprising:  
disposing said diodes in said line lengths, spaced apart from junctions of said line lengths  
to prevent opposite phased power leakage cancellation between different ones of said lines.

123. The method of claim 120 further comprising:  
disposing said diodes in said line lengths, spaced apart from junctions of said line lengths  
to cancel resonance effects in said lines.

124. The method of claim 79 further comprising:  
feeding said elements, by said feed network, using two orthogonal branches.

125. The method of claim 124 further comprising:  
providing two orthogonal phases using a phase shifter of said feed network; and  
selectively switching a feed to one of said orthogonal branches.

126. The method of claim 79 wherein said feed network comprises differential feeds  
for said elements.

127. The method of claim 126 further comprising:  
providing signals to said elements 180 degrees out of phase using said differential feeds  
for said elements.

128. The method of claim 79 further comprising:  
detecting faults in said feed network by sensing current to assess the current drawn by  
said phase shifters of said feed network, thereby determining proper operation of said feed  
network phase shifters.